

STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: 9. *CYPERUS PROLIFER* LAM. AND SOME ALLIED SPECIES

H. BAIJNATH¹ AND F. M. GETLIFFE²

(University of Durban-Westville)

ABSTRACT

The biology of *C. prolifer* Lam. and its allies *C. sensilis* Baijnath and *C. x. turbatus* Baijnath is discussed. The value of traditional diagnostic criteria is examined and data from fields of morphology, cytology, anatomy and phytochemistry employed to justify the specific recognition of these taxa. Keys to their identification are provided.

UITTREKSEL

STUDIES VAN CYPERACEAE IN SUIDELIKE AFRIKA: 9. *CYPERUS PROLIFER* LAM. EN 'N PAAR VERWANTE SOORTE

Die biologie van *C. prolifer* Lam. en sy verwante soorte, *C. sensilis* Baijnath en *C. x. turbatus* Baijnath, word bespreek. Die waarde van tradisionele diagnostiese kenmerke word ondersoek. Morfologiese, sitologiese, anatomiese en fitochemiese kenmerke word gebruik om tussen hierdie soorte te onderskei. Sleutels word verskaf.

INTRODUCTION

The coastal vegetation of Natal and Zululand includes the southern limits of many tropical species. One such species is *C. prolifer* Lam., the so-called "miniature papyrus." Associated with *C. prolifer* are two new taxa *C. sensilis* Baijnath and *C. x. turbatus* Baijnath which have a more restricted distribution being limited, we believe, to the east coast of Southern Africa.

The nomenclatural confusion which surrounds *C. prolifer* has been discussed earlier (Getliffe and Baijnath, 1976) and the present paper compares this taxon and its allies, *C. sensilis* and *C. x. turbatus* (Baijnath, 1976), and aims to justify their recognition as species and to provide adequate keys to their identification.

TAXONOMIC POSITION WITHIN *CYPERUS*

By virtue of their umbellate inflorescences, digitate or solitary spikelets and wingless rhachillas, all three species are placed within the subgenus *Pycnostachys* (Clarke, 1897), while their leafless habit places them in section 5 *Textiles* of this subgenus (Clarke, 1902).

Within this section, diagnostic characters include size and number of bracts, culm shape and ray number. Thus, Clarke distinguished two species, *C. prolifer*

1. Present address: Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey.

2. Present address: Botany Department, University of the Witwatersrand.

Lam. and *C. isocladius* Kunth (now regarded as synonyms, Getliffe and Baijnath, *l.c.*) solely on basis of culm shape. As Clarke pointed out, the value of such a differentiation is debatable and this and other diagnostic and descriptive characters were studied and will be discussed below.

MATERIAL

Material for the comparison of the three species and study of variation within species was obtained from mass collections of 20 specimens gathered at random from populations from the range of distribution of each taxon.

Appendix 1 provides citations of specimens used in this study.

MORPHOLOGICAL FEATURES

(i) Culm shape

Though several authors have expressed reservations about the wisdom of relying on culm shape as a diagnostic criterion (Boeckeler, 1867–68, Clarke, 1897, Forbes, 1969) it is, nevertheless, often used in keys to distinguish pairs of similar species.

There are two serious disadvantages in this use of culm shape as a diagnostic criterion. The first is the lack of uniformity in terminology, the second the lack of adequate information on variation within populations and indeed within a single specimen.

In the analysis of descriptive terms used for culm shapes in *C. prolifer* Lam. it was apparent that there was little consistency in the use of the terms "triquetrous", "trigonus" and "triangular" and some confusion over the exact definitions of these terms.

According to Featherley (1965) the terms "trigonus" and "triangular" are synonyms while Stearn (1973) remarks that "trigonus" and "triquetrous" are usually considered synonyms. These two latter terms were used to separate *C. isocladius* Kunth and *C. prolifer* Lam. (Kunth, 1837).

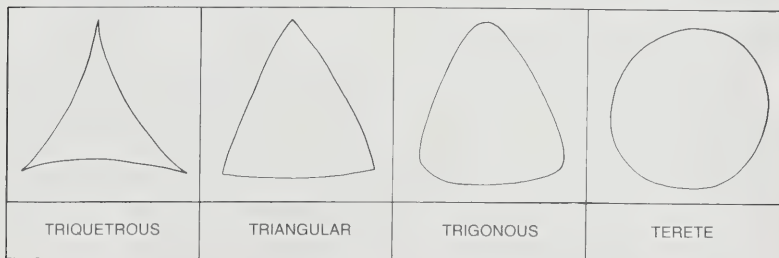


FIG. 1

Culm shape in *Cyperus* and the descriptive terminology used in this text.

In this study, the terms "terete", "trigonous", "triangular" and "triquetrous" are used to describe culm shape in cross section and the shapes they describe are illustrated in Fig. 1.

Thus, "terete" is applied to culms which are circular in trans sectional outline, "trigonous" to those which are triangular in cross section, with obtuse angles, "triangular" to three-angled stems with acute angles and "triquetrous" to three-angled stems with acute angles and concave faces.

Population samples of ten specimens from each of three populations of *C. prolifer* (Bajinath 745, 746, 763), two populations of *C. x turbatus* (Bajinath 747, 752) and one of *C. sensilis* (Bajinath 794) were collected and sectioned at base, midway and apex of culms. Sections, mounted in safranin-glycerin jelly, were illustrated using a Magnifax photographic enlarger and the results are summarised in Table 1.

TABLE 1

Variation in culm within populations of *C. prolifer*, *C. sensilis* and *C. turbatus*. The number of culms exhibiting each shape is given in parenthesis and the collector in each case was H. Bajinath. For details see Appendix 1.

SPECIES	Collector's Number	SHAPE		
		Base	Midway	Apex
<i>Cyperus prolifer</i> . . .	763	terete (3) trigonous (9)	terete (2) trigonous (7) triangular (3)	terete (1) trigonous (6) triangular (5)
	745	terete (7) trigonous (8)	trigonous (12) triangular (3)	terete (1) trigonous (6) triangular (3) triquetrous (5)
	746	terete (8) trigonous (2)	terete (4) trigonous (6)	trigonous (10)
<i>Cyperus x turbatus</i>	752	terete (7) trigonous (3)	terete (5) trigonous (5)	trigonous (10)
	747	terete (9) trigonous (1)	terete (7) trigonous (3)	terete (2) trigonous (8)
<i>Cyperus sensilis</i> . . .	794	terete (10)	terete (10)	terete (10)

In *C. prolifer* and *C. x turbatus*, considerable variation was evident. In each culm, there was a tendency for a gradual change from a terete or trigonous base to a triangular, triquetrous or trigonous apex, though in each taxon a few exceptions remained terete throughout.

C. sensilis exhibited less variation. The population sampled had uniformly terete culms. This is true of other populations studied, with the exception of one (Bajinath 665) in which triangular forms were noted.

It appears therefore that caution must be exercised in basing identifications solely on this character. On the whole, *C. sensilis* seems to be distinguished from the other two species by its uniformly terete culms, but this cannot be relied upon without reference to other features.

As culm shape is not always easily determinable from herbarium specimens, it is suggested that this feature would be of greater value in field recognition than in formal keys where it should only serve as an auxiliary characteristic.

(ii) Inflorescence structure

(a) Ray length and number

In the early descriptions of *C. prolifer*, much emphasis was placed on features of the inflorescence such as number of rays, ratio of lengths of rays within a head and average ray length.

These and other inflorescence features were compared using population samples of the following gatherings:

Bajinath 682, 710, 740, 743 (*C. prolifer*); Bajinath 752, (*C. x turbatus*); and Bajinath 794 and Ward 6804 (*C. sensilis*).

Ray length was measured from the base to the first branch of each ray. Ray lengths were divided into classes of 1 cm units and the relative proportion of long and short rays assessed by comparing the distribution in these classes.

The results are summarised in Fig. 2.

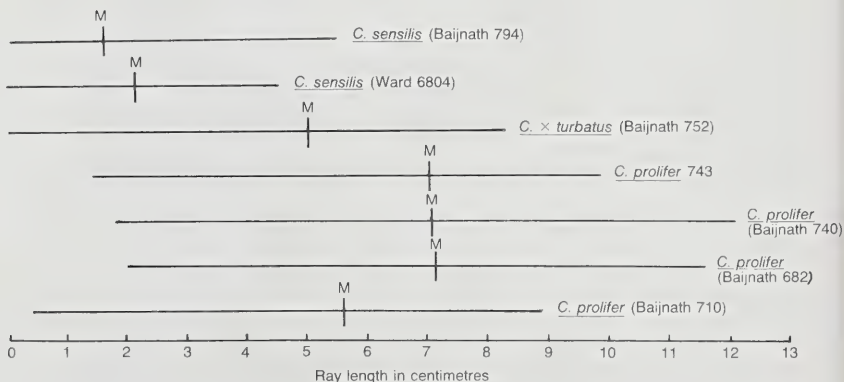


FIG. 2

Range of ray length and mean ray length (M) calculated from measurements of at least ten individuals from populations of *C. prolifer*, *C. x turbatus* and *C. sensilis*.

Ray length is, however, of little value in distinguishing these species (see Fig. 2).

The terms "equal rayed" or rays "subequal" are often applied to *C. prolifer* and Figure 3 represents an analysis of the relative lengths of rays in the three taxa being studied. The absence of very clear peaks and the presence of conspicuous numbers of rays both longer and shorter than the majority suggest that the term "equal rayed" is a misnomer and "subequal" seems scarcely justified as the range is wide.

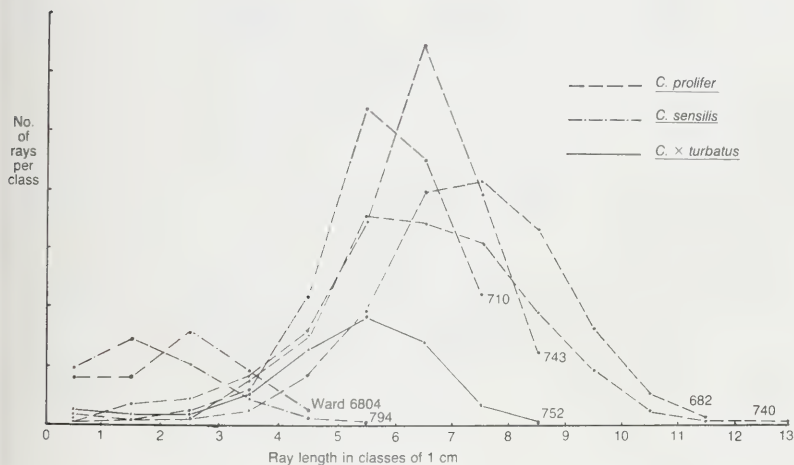


FIG. 3

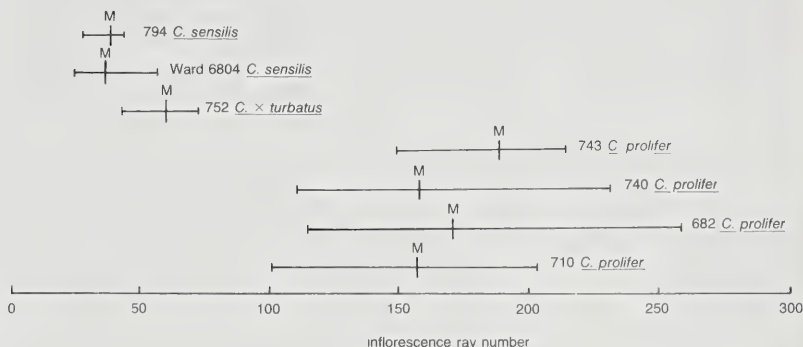
General frequency polygrams illustrating the range of inflorescence ray length within populations of *C. prolifer*, *C. sensilis* and *C. x turbatus*. Unless otherwise indicated, the collector's number refers to a Baijnath gathering.

Ray number was one of the features emphasised in early descriptions of *C. prolifer* which was variously described as having "50-100 rays", "numerosimilis" or "100 or more rays". In the present study, a range from 101-259 with an average of 171 confirms that *C. prolifer* is indeed characterised by this feature and distinguished thereby from *C. x turbatus* and *C. sensilis* with fewer rays.

This study, therefore, confirms that ray number is a valid diagnostic criterion on which to distinguish *C. prolifer* from its allies, but does not support the emphasis on proportion of ray length as a diagnostic feature of any of the three species. *C. sensilis* and *C. x turbatus* are not reliably distinguishable on number of rays though *C. sensilis* appears, on average, to have fewer rays.

(b) Ray receptacle, umbel shape, spikelet number

Umbel silhouette has proved to be a useful field character and, if material is pressed with care, it is retained in herbarium specimens. The characteristic shapes are dependent on two features, ray number and ray receptacle shape.



Range of variation in ray number and mean ray number (M) calculated from populations of at least ten individuals of *C. prolifer*, *C. sensilis* and *C. x turbatus*. Unless otherwise indicated, the collector's number refers to a Baijnath gathering.

In *C. prolifer*, the numerous rays are borne on a spherical receptacle which results in an umbel which is almost spherical. When carefully pressed, these umbels flatten to a circle of rays with a conspicuous circle of tubular prophylls about the central axis.

In *C. sensilis*, with fewer rays on an awl-shaped receptacle, the umbel is a narrow sector of a sphere with the acute angle between extremes of the sector limits. *C. x turbatus* has an ovate receptacle with a filiform apex and the umbel is therefore a wider sector of a sphere. These and other features of the inflorescences are illustrated in Fig. 5.

In the bud stage, shape of bud and size of bracts can be used to distinguish these taxa. *C. prolifer* with its stout bud and long inferior bract averaging 4 cm and extending beyond the bud cluster is separated from *C. x turbatus* with a shorter inferior bract. *C. sensilis*, as could be expected from shape of ray receptacle, has a narrow elongated bud (see Fig. 5). Frequently the bract in *C. sensilis* remains upright even after the bud break, so that the umbel appears to be lateral.

Number of spikelets per ray varied among the species (see Fig. 5) and gave a useful visual aid to the identification of the species and combined with ray number in a scatter diagram serves to separate the taxa (see Fig. 6).

Thus, inflorescence features such as form of umbel, shape of receptacle, ray number and bract length provide useful diagnostic characters of value both in field recognition and identification of herbarium material.

CHEMICAL CHARACTERS

A one-dimensional survey of pigments of culm, inflorescence, and rhizome revealed that there was no variation within populations or between populations of

Character	<i>C. prolifer</i>	<i>C. × turbatus</i>	<i>C. sensilis</i>
UMBEL SILHOUETTE			
BUD SHAPE			
BRACT orientation			
shape of receptacle			
inflorescence ray form			

FIG. 5

Some diagnostic characters of *C. prolifer*, *C. × turbatus* and *C. sensilis*.

a single species. Culm extracts, however, revealed difference between species and a two dimensional study of the culm pigments was undertaken.

Direct extracts of culm samples were obtained by boiling material in ethanol over a waterbath for 5 mins. The extract was concentrated and spotted up on Whatman No. 1 chromatography paper (57 × 47 cm) prepared for descending chromatography. The chromatogram was developed in BAW (butanol-acetic acid-water) and 5% acetic acid.

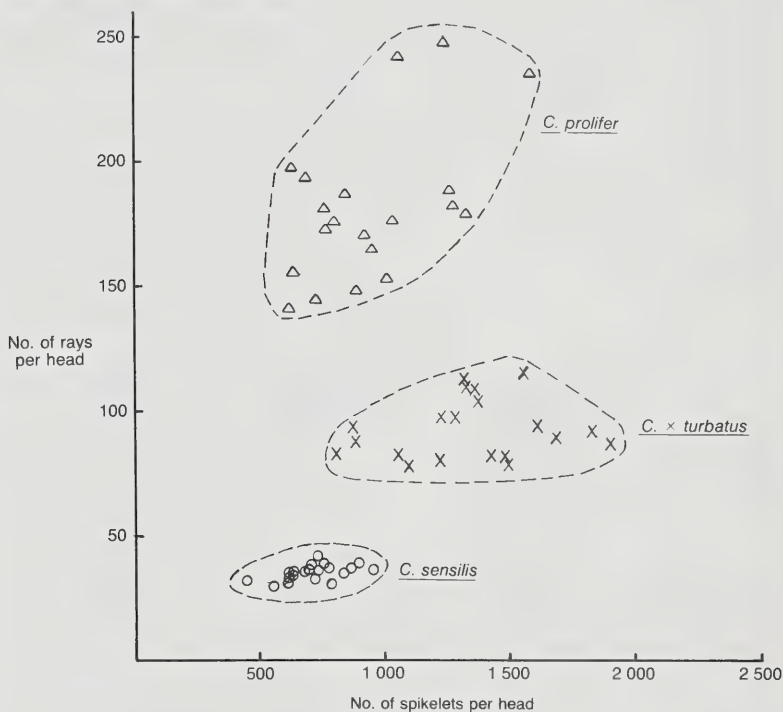


FIG. 6

Scatter diagram in which the number of inflorescence rays in heads of *Cyperus* species is contrasted with the number of spikelets per head.

Spots were located under ultra-violet light and colour changes on fuming with ammonia were recorded. The R_f in both solvents was calculated.

Thirty five spots were recorded and species-specific patterns were found. A large number of the spots were caffeic acid derivatives, but conspicuous flavone glycoside spots were present. The compounds were not identified but, on basis of colour and R_f , it is probable that triclin occurs in *C. prolifer* and that luteolin may



UNIVERSITY COLLEGE, DBN. HERBARIUM
11/2 RACCAK

Cyperus

Close to national road in moist depression
blackish clayey sand. Common. Flower umbels

abundant. No evidence of leaf blades

near NATAL. 3000 DA (Port Shepherson). Tinten,
S of Lupton turnoff [Unfayuan River S] [30° 31' S, 30° 31' E]

coll. H. BAIRDATH.

coll. No. 710

1921.58 Feb. 1970.6

FIG. 7
An herbarium specimen of *C. prolifer* collected prior to burning. Leafless culms are present.



FIG. 8

An herbarium specimen of *C. prolifer* from Merebank collected after burning. Leaf blades have been produced in the regenerating material.

be common to all three. Isolation and comparison with authentic compounds was outside the scope of this study.

Although there was a common core of compounds present in all three species, their patterns were distinctive with *C. prolifer* and *C. sensilis* possessing some unique spots. The basic similarity in 'fingerprint' patterns may reflect generic characteristics and studies of other species is necessary. Nevertheless, the patterns were sufficiently distinct to suggest that the three taxa were separate entities.

REACTION TO DENUDATION

Although the three species under discussion are generally leafless, as are all members of the section *Textiles*, occasionally, during the course of this investigation, specimens bearing short laminae in addition to the normal leaf sheath were collected. These leafy forms were found in populations which were regenerating after fire and Figs. 7 and 8 show successive collections of *C. prolifer* from Merebank before and after fire.

After fire, the regenerating plants were stunted but prominent bracts and leaf blades were visible. Similar reactions in grasses have long been utilised in research on pasturelands, to increase nutritive properties (Smith and Young, 1959), succulence (Vogl, 1965) and biomass (Hadley and Kieckhefer, 1963). There is also some debate as to whether mowing would have similar effects (Wright, 1969; Knight 1970). Little comment on this phenomenon in sedges has been recorded, however, and an experiment in controlled burning and mowing of *Cyperus* was carried out during the course of this study.

Two experimental areas at Merebank and at Clairwood Racecourse proved suitable for experiments on all three species.

Representative herbarium specimens of each species were collected from each site. The plots were divided into three areas. Plot 1 was burnt, with the addition of dry vegetation to simulate a veldfire. Plot 2 was cut to a height of 2–3 cm and plot 3 left as the control.

Progress was recorded at weekly intervals for 10 weeks by photographs, notes and collections.

Regeneration of *C. prolifer* involved the development of leaf blades, increase in numbers of culms, but decrease in height and diameter of culms, reduction in number and length of inflorescence rays, but increase in length of bracts.

C. sensilis, on regeneration, flowered and produced a few minute leaf blades while *C. x turbatus* exhibited only an increase in flowering.

These responses suggest that under stress, survival of *C. prolifer* is likely to be through rapid vegetative growth to promote maximum photosynthetic tissue to provide adequate reserves in rhizomes and latent vegetative buds, while in the other two species response to stress is the production of flowers.

ANATOMY

The three species under consideration were not included in the recent survey of anatomy of *Cyperus* L. (Metcalf, 1971) and a detailed anatomical study was undertaken.

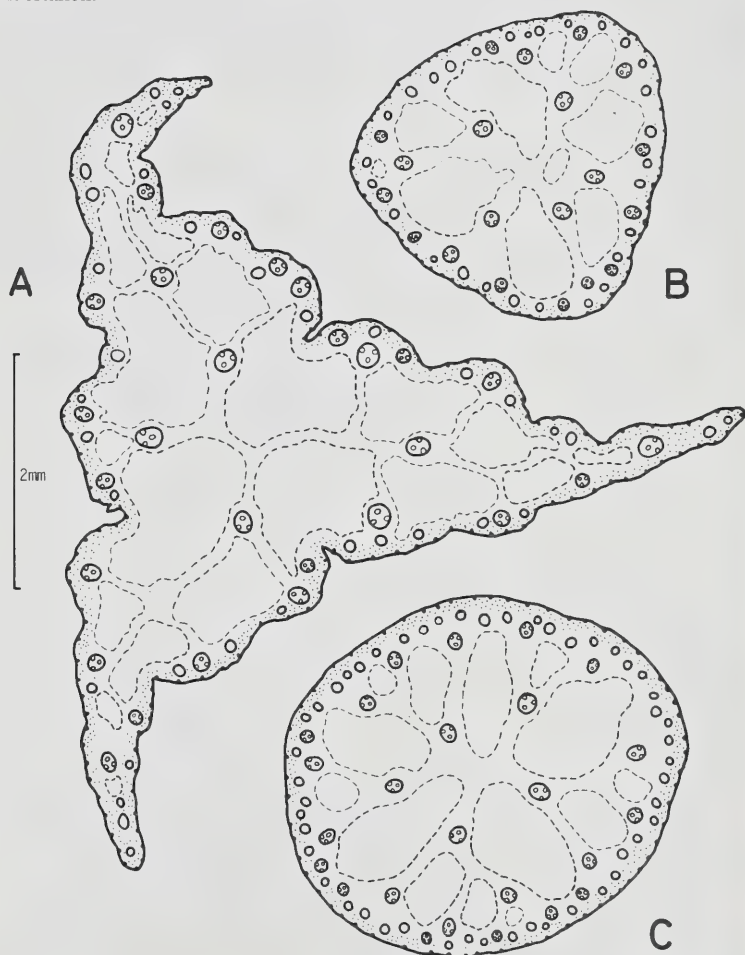


FIG. 9

Plan of the distribution of tissues in transverse sections of culms of *C. prolifer* (A), *C. x turbatus* (B) and *C. sensilis* (C). Dotted lines indicate boundaries of air spaces and stippled area represents the chlorenchyma.

Roots, rhizomes and culm bases showed little of diagnostic importance but, as predicted by Metcalfe (*l.c.*) bracts and culms were more useful.

Mid-portions of bracts and culms were dehydrated and embedded in wax following standard procedures, and transverse sections prepared with a Leitz sledge microtome.

In transverse sections the shapes of the culm were often characteristic of the species (see Fig. 9) but as we have indicated, this feature is not entirely reliable.

Vascular bundles are distributed in a peripheral chlorenchymatous zone with a few present at the interstices of the translucent mesh of stellate parenchyma which composed the major part of the section.

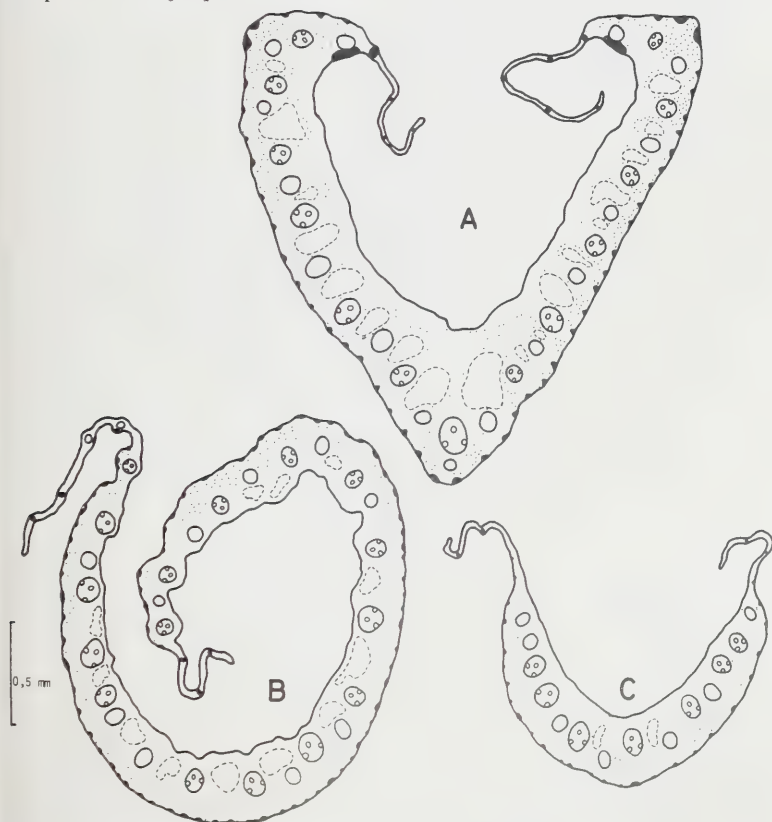


FIG. 10
Plan of distribution of tissues in transverse sections of involucre bracts of *C. prolifer* (A),
C. x turbatus (B) and *C. sensilis* (C).

A heavily cuticularised epidermis is present in all three species, but *C. prolifer* is distinctive as epidermal papillae are frequent here. Papillae are occasionally found in *C. x turbatus* but absent in *C. sensilis*. Metcalfe (*l.c.*) noted that epidermal papillae are uncommon in *Cyperus* and their presence here may be of

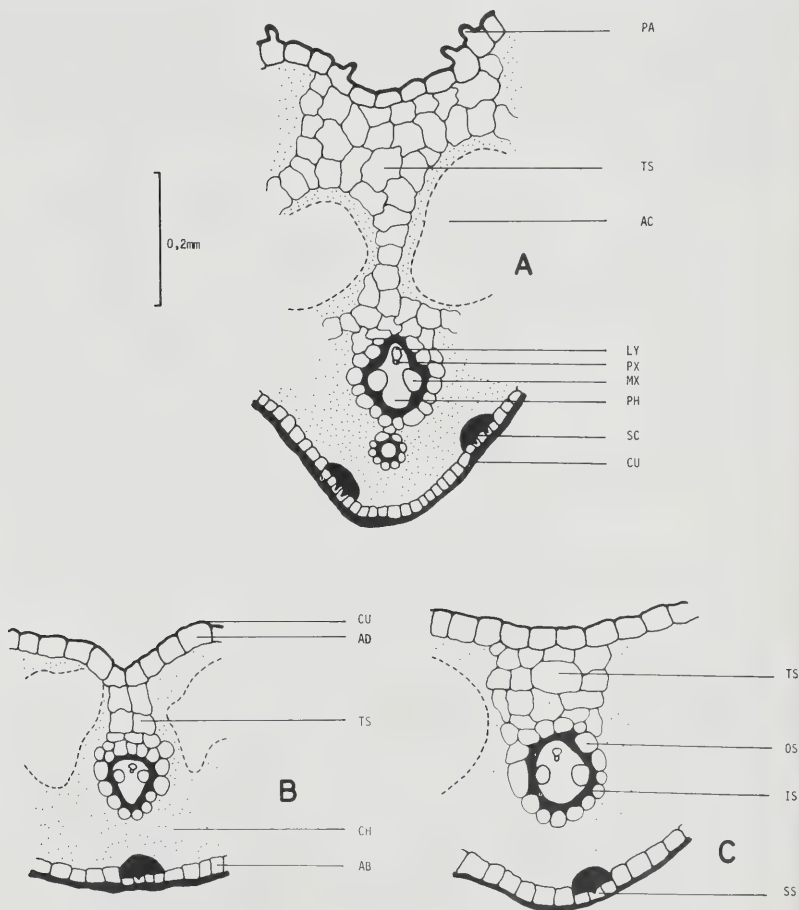


FIG. 11

Semi-detail of the central portion of the involucre bracts of *C. prolifer* (A), *C. x turbatus* (B) and *C. sensilis* (C). (AB- abaxial epidermis; AC- air cavity; AD- adaxial epidermis; CH- chlorenchyma; CU- cuticle; LY- protoxylem; MX- metaxylem; OS- outer sheath; PA- papilla; PH- phloem; PX- protoxylem; SC- sclerenchyma; TS- translucent hypodermis.)



FIG. 12
Vegetative proliferations arising from the axils of involucral bracts in *C. prolifer*.

importance. Further examples within the genus should be studied to assess the taxonomic value of such a feature. Conical silica bodies characteristic of *Cyperus* are features of the epidermis.

The peripheral chlorenchyma is interrupted by regular clusters of sclerenchyma strands and occasional tanniniferous cells are present. Second and third order vascular bundles are found in the peripheral chlorenchyma, and first order bundles at the interstices of the ground aerenchyma. An inner sclerenchyma and outer chlorenchyma sheath enclosed each bundle. The ground tissue consists of a reticulum of stellate parenchyma. In it are cavities formed by the disintegration cells. Stellate parenchyma had been reported in the genus (Fahn, 1974).

Transverse sections of the bracts have distinctive shapes (see Fig. 10) and the median bundle also reveals some notable distinguishing features (see Fig. 11).

Bracts of *C. prolifer* possess two median bundles, a larger first order and a smaller third order bundle both enclosed in conspicuous inner sclerenchyma and outer parenchyma sheaths. In addition, paired sclerenchyma strands are situated abaxially at the mid vein of the bract. *C. prolifer* has epidermal papillae on the bracts.

C. x turbatus and *C. sensilis* have single median bundles and sclerenchyma strands and are without papillae.

Of added value are the mid axial hypodermal layers of large parenchymatous translucent cells. In transverse sections, this layer is T-shaped in *C. prolifer*, square in *C. x turbatus* and almost circular in *C. sensilis*.

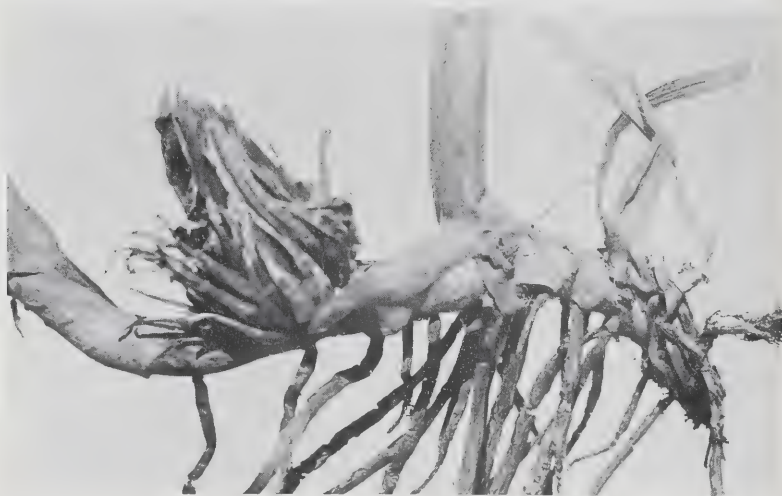


FIG. 13

Bulbils produced at the base of the culm in *C. prolifer*.

Although in many respects, these species are anatomically similar, differences in bract shape vascular arrangement, translucent tissue and epidermis may be used to distinguish between them.

VEGETATIVE REPRODUCTION

Although a wider study of vegetative reproduction in *Cyperus* is anticipated, it is pertinent to comment here on the variety of forms of vegetative reproduction encountered in this group of species.

C. prolifer, as its epithet implies, frequently exhibits vegetative proliferations. These commonly arise in the axiles of involucre bracts (see Fig. 12), from the apices of inflorescence rays, by modifications of spikelets and by means of bulbils (Fig. 13) produced at or near culm bases.

C. x turbatus has been seen to proliferate like *C. prolifer* and also exhibits rapid growth of slender culms under conditions of stagnation. *C. sensilis*, though much less active in this respect does occasionally show a reaction to stagnation of the same form as in *C. x turbatus* (Fig. 14).



FIG. 14

Proliferation of fine 'Grass-like' culms of *C. x turbatus* in response to stagnant conditions.

CONCLUSION

C. prolifer, *C. x turbatus* and *C. sensilis* appear to be discrete with specific ecological preferences. They are distinguishable on morphological features of inflorescence form as well as on anatomical and chemical grounds. Traditional diagnostic characteristics of culm shape have been found to be less valid than

features of inflorescence form and keys to the identification of these taxa are provided below. The first is based on features which could be observed in field or herbarium specimens, the second chiefly on ecological preferences.

KEY

Rays 101–259 in umbel, forming almost spherical inflorescence; inferior involucre bracts usually 3 cm long, V-shaped in transverse section, with two vascular bundles and an hypodermis 9–12 cells deep in the mid vein **C. prolifer** Lam.
 Rays 25–73, in a compact raceme forming a narrow sector of a sphere; inferior involucre bract usually <3 cm long, variable, but not V-shaped in transverse sections, with one vascular bundle and hypodermis 2–5 cells deep in the mid vein.
 Rays 42–73, forming obtuse angle at culm apex; ray receptacle ovoid with extended filiform apex; inferior involucre bract c. 2 cm long; papillae sometimes present on culm epidermis **C. x turbatus** Baijnath
 Rays 25–57, forming an acute angle at culm apex; ray receptacle filiform; inferior involucre bract c. 1 cm long; invariably without papillae **C. sensilis** Baijnath

FIELD KEY

Vegetative reproduction occasionally by means of rapid proliferation of fine culms ("grass-like" growth), not associated with inflorescence or spikelet; sterile rays never extended; inflorescence receptacle filiform **C. sensilis** Baijnath

Vegetative reproduction by proliferations associated both with vegetative parts and inflorescence and spikelet; sterile and fertile rays extended; inflorescence receptacle ovoid to spherical.

Reactions to stagnating conditions by rapid proliferation of fine culms ("grass-like" growth); bulbils absent; populations dormant in winter; inflorescence receptacle ovoid with filiform point **C. x turbatus** Baijnath

Intolerant of stagnating conditions, grasslike growth not exhibited; bulbils common; populations active throughout year; inflorescence receptacle spherical **C. prolifer** Lam.

ACKNOWLEDGEMENTS

One of us (H.B.) wishes to acknowledge with gratitude, the financial support of the Council for Scientific and Industrial Research and South African Sugar Association and a Travel Grant to Mauritius, from the S.C.D.I.F.A. and Maistry Educational Trusts. We are grateful to Dr K.D. Gordon-Gray for her careful perusal of the manuscript and her helpful comments thereupon and to Mrs L. Mulder for her assistance in preparation of illustrations.

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APPENDIX 1

Citations of specimens used in studies of morphological, anatomical and chemical characters of *C. prolifer* Lam., *C. sensilis* Baijnath and *C. x turbatus* Baijnath.

C. prolifer

Baijnath

- 682 3030 BC, (Port Shepstone): Umzinto Park Rynie Road, *II*. 1970.
- 710 3030 DA, (Port Shepstone): Turton Umfazazaan River South (S. of Isipofu turn-off), *II*. 1970.
- 740 3030 BC, (Port Shepstone): Park Rynie Roadside, *IV*. 1970.
- 743 2930 DD, (Pietermaritzburg): Merebank S.W., *IV*. 1970.
- 745 3030 CD, (Port Shepstone): Shelley Beach, *V*. 1970.
- 746 3030 (Port Shepstone): Shelley Beach, *V*. 1970.
- 763 2930 DD, (Pietermaritzburg): Clairwood Race Course, *IX*. 70.

C. sensilis

Baijnath

- 665 2832 AD, (Mtubatuba): St. Lucia Park, *XI*. 1969. 794 2930 DD, (Pietermaritzburg): Happy Valley Bird Sanctuary. 1970.
- Ward 6804 2832 AB, (Mtubatuba): Makhakhatana, *XI* 1969.

C. x turbatus

Baijnath

- 747 3030 CD, (Port Shepstone): Shelley Beach, *V*. 1970.
- 752 3030 BC, (Port Shepstone): Umdoni Park. 1970.